Ozone-On-Demand™ Reduces Water Treatment Cost By 20%

Pinnacle Ozone Solutions' new generation of smart Ozone-On-Demand (OOD™) generator and control technology can help significantly reduce the cost and complexity of ozone water treatment. By precisely matching ozone production to real-time demand, the North Burleigh Water Treatment Plant (WTP) near Bismarck, North Dakota increased treatment capacity by 64% while simultaneously reducing unit-operating cost by over 20%. The results clearly demonstrate that newer, more efficient ozone generation and controls technologies are ideally suited for small to medium treatment plants, especially those using membranes.

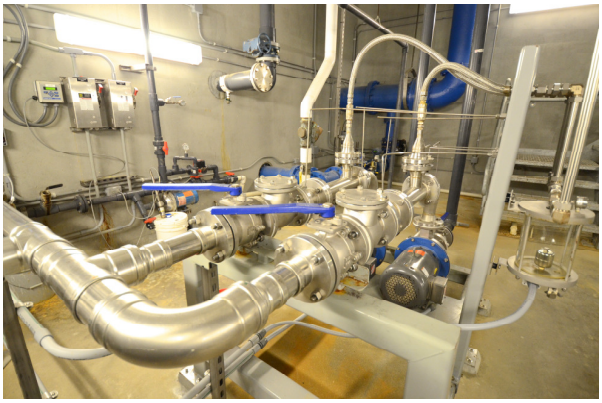
Since its construction in early 2005, the North Burleigh Water Treatment Plant near Bismarck, North Dakota has used ozone in both its pre-treatment and disinfection process steps. Although many treatment plants experience seasonal variations in raw water quality, the conditions at the Burleigh site are especially challenging. Because the plant draws raw water from a series of angle wells drilled beneath the Missouri River, even slight changes in river water level or quality influence the incoming mix of surface and groundwater. Especially challenging are concentrations of dissolved iron (Fe), manganese (Mn), and dissolved organic carbon (DOC) can often reach 5.0 mg/l, 0.8 mg/l, and 3.4 mg/l, respectively, and can fluctuate by more than 30% throughout any given day.

To improve treatment, the Burleigh plant uses ozone for both pre-treatment and disinfection. However, managing ozone demand and production was a real challenge. To compensate, the plant often ran its older air-based ozone system at 100% capacity and then dosed 10-15 mg/l of sodium bisulfite to prevent damage to the downstream microfiltration – reverse osmosis (MF-RO) membranes. While effective, this process was difficult to manage, inefficient, and costly to operate.

In 2009 the South Central Regional Water District (SCRWD) began plans to double the capacity of the MF-RO system to meet increasing water demand. After completing a thorough review of the options, Mr. Joe Honner, P.E. of Bartlett & West Engineers determined that upgrading the Burleigh Plant's ozone system could greatly benefit treatment efficiency. To meet this objective, the new ozone system would need to match ozone dose with real-time process conditions in order to minimize the need for costly quenching chemicals and lower total treatment cost.

After a thorough review of competitive bids, the S. Roberts Company and Pinnacle Ozone were selected to provide a new integrated ozone system for the project. The chief advantage of the new Pinnacle system is its Ozone-On-Demand™ control process, which can precisely match ozone production to actual real-time demand. This technique reduces operating costs by optimizing all aspects of ozone production across the full 0-100% turn-down capacity of the system.

Pinnacle's Summit™ series ozone generator also offers other advantages to the project. The a modular design of the system consists of up to ten independent ozone generator units that can provide up to 120 pounds of ozone per day at a concentration of 6-10% by weight. Higher ozone concentrations are made possible by feeding the ozone generator with 93% pure oxygen which is supplied by a Pacific Consolidated Industries (PCI) vacuum swing adsorption (VSA) system. The system also includes two fully independent ozone dosing systems which feature Mazzei injector technology. All of the system components are controlled from a central PLC which calculates total ozone demand and optimizes the control and performance of all aspects of the treatment process.



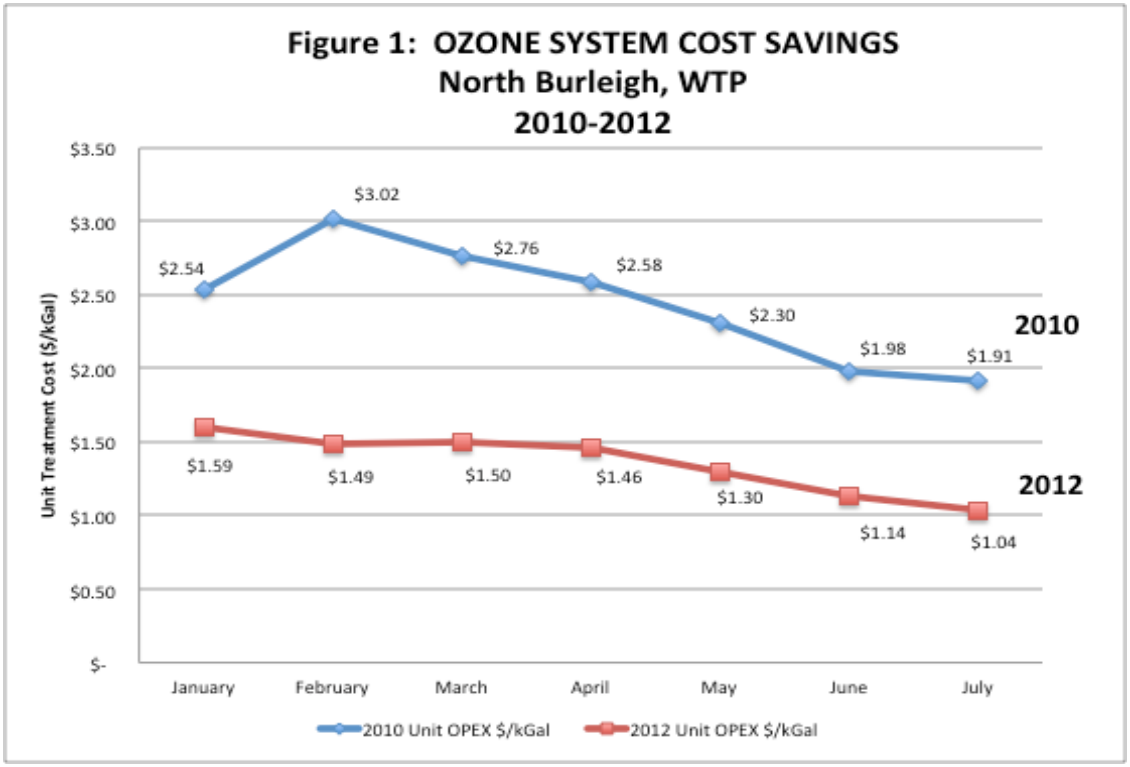
Pinnacle's Ozone-On-Demand system also offers other important benefits. The modular design of the ozone generator allows for complete built-in redundancy and eliminates the need for costly standby equipment. Since each of the ozone generator units has its own integrated power supply, the need for large power transformer sets is eliminated. Also eliminated are concerns over ambient noise since the system operates beyond the audible range at 23kHz. An added benefit of the high operating frequency is a dramatic reduction in power-line harmonics and electromagnetic interference at the site. Finally, the modular design is extremely space efficient and is 35% smaller than similarly sized conventional ozone equipment. Overall, these benefits make the Pinnacle system much easier to install, locate and operate.

The North Burleigh plant completed installation and startup of the new ozone system in April 2011. Shortly after startup a series of devastating floods inundated much of the Bismarck area from May through September. Despite the significant operating challenges, the new ozone system remained online 100% of the time since startup with minimal service downtime.

To date, the performance benefits of the ozone system have exceeded all expectations. Evaluation of operating data from the same seven-month period before and after the floods (January-July 2010 and 2012) show that the Burleigh WTP has *increased treatment capacity by 64% with a simultaneous 56% reduction in unit operating cost over the same period.* (Table I and Figure 1). As a result of the increased capacity, the Burleigh WTP has reduced its wholesale purchases of water from the City of Bismarck by 50-80%. Further evaluation show that these results were achieved despite a net 8% increase in unit chemical cost, and 10% increase in unit power costs over the same two-year period. Overall, the new ozone system has allowed net savings in almost every area of WTP operations despite the increase in WTP capacity.

TABLE I: NET OPEX SAVINGS 2010-2012
North Burleigh, WTP, Bismarck, ND

Month	Power $/kgal	Chem $/kgal	Supply $/kGal	Maintenance $/kGal	Labor $/kGal	Source Maint $/kGal	Testing $/kGal	Unit OPEX $/kGal
January	23%	5%	-70%	-63%	-68%	109%	-59%	-37%
February	-4%	-18%	-76%	-71%	-75%	64%	-68%	-51%
March	6%	-9%	-74%	-68%	-72%	81%	-65%	-46%
April	11%	-5%	-73%	-67%	-71%	88%	-63%	-43%
May	10%	-6%	-73%	-67%	-71%	87%	-64%	-44%
June	12%	-4%	-72%	-66%	-71%	91%	-63%	-43%
July	6%	-9%	-74%	-68%	-72%	80%	-65%	-46%
Annual Avg:	**9%**	**-7%**	**-73%**	**-67%**	**-72%**	**86%**	**-64%**	**-44%**



A more detailed evaluation to total electrical costs for the WTP is presented in Table II. The data show the aggregate (ie: total) electrical use (kWh) and cost for the same period of normal operation before and after the new ozone system. Monthly total and unit electrical use for the first six months of 2010 and 2012 are compared against the increased treatment capacity during the same period. Similarly, peak electrical use is tabulated and compared since it can represent as much as 50% of monthly power bill. The results summarized at the bottom of Table II show that unit electrical costs are 3-25% lower with more efficient ozone treatment. More significantly, these results were achieved despite a 29-75% increase in peak electrical charges during the same period. *Overall, the plant has achieved a 10% reduction in unit energy use despite a 65% increase in capacity*. Based on these results the WTP is investigating means of reducing its electrical use during peak periods to capture a greater portion of energy savings.

TABLE II: EVALUATION OF WTP ELECTRICAL USE AND COST
North Burleigh WTP, Bismarck, ND

YEAR 2010 Month	Treated Vol (gal)	Tot Elect Use (kWh)	Peak Elect (kWh)	WTP Elect Cost	Unit Elect Use (kWh/kgal)
Jan	17,082,500	95,640	288	$ 7,538.00	5.60
Feb	15,399,000	92,280	303.6	$ 7,518.00	5.99
Mar	15,618,400	99,000	326.4	$ 8,070.80	6.34
Apr	17,392,800	95,400	283.2	$ 7,480.49	5.49
May	21,642,200	99,360	295.2	$ 7,792.40	4.59
Jun	27,658,600	113,400	312	$ 8,654.00	4.10
YEAR 2012 Month	**Treated Vol (gal)**	**Tot Elect Use (kWh)**	**Peak Elect (kWh)**	**WTP Elect Cost**	**Unit Elect Use ($/kgal)**
Jan	25,039,950	133,920	430	$ 12,551.14	5.35
Feb	25,126,700	142,320	470	$ 13,518.34	5.66
Mar	29,024,300	137,880	420	$ 5,330.00	4.75
Apr	29,013,500	154,920	420	$ 12,632.26	5.34
May	35,909,200	146,040	521	$ 14,366.98	4.07
Jun	44,556,000	167,400	542	$ 15,742.90	3.76

PERECENT DIFFERENCE 2010 - 2012

Month	Delta Vol (%)	Delta Elect (%)	Delta Peak Elect (%)	Delta Elect Cost (%)	Delta Unit Elect Cost (%)
Jan	*147%*	*140%*	*149%*	*167%*	*96%*
Feb	*163%*	*154%*	*155%*	*180%*	*95%*
Mar	*186%*	*139%*	*129%*	*66%*	*75%*
Apr	*167%*	*162%*	*148%*	*169%*	*97%*
May	*166%*	*147%*	*176%*	*184%*	*89%*
Jun	*161%*	*148%*	*174%*	*182%*	*92%*
Average:	*165%*	*148%*	*155%*	*158%*	*90%*

Overall, the increase in WTP performance from the new ozone system at the Burleigh WTP is remarkable. The results reveal that carefully selected ozone equipment and Pinnacle's Ozone-On-Demand controls system can result in significant improvements in overall WTP performance. While the aggregate data presented here provide a good overview, discussion with Mr. Douglas Neibauer, Executive Director of the North Burleigh WTP, provided further insights into how these results were achieved.

- Improved instrumentation in both pre-treatment and disinfection allow for accurate estimates of real-time ozone demand under any raw water quality conditions.
- Advanced controls built into the ozone generator platform allow for precise "on-demand" optimization of all ozone process parameters to match process conditions.
- Integration of both on-site oxygen production and ozone generation precisely matches production needs and eliminates wasted power. Integrated control of ozone system cooling water pumps further reduces wasted power.
- Precise ozone dosing significantly improves pre-treatment performance for the removal of dissolved Fe, Mn, and TOC, which in turn reduces the need for flocculation chemicals. The use of quenching chemical after pre-treatment has been reduced by 60-75%. Both factors improve performance and reduce fouling, as well as cleaning, of the MF and RO membrane processes.
- The rugged modular ozone system design of the ozone generator significantly reduces maintenance requirements and provides built-in redundancy, as well as standby capacity, to meet unexpected operating conditions.

As further testament to the project's success, the SCRWD installed an identical Pinnacle Ozone system during the construction of the Emmons County WTP in June 2012. After commissioning the second plant, Mr. Neibauer commented, "the ozone controls for both the Emmons and North Burleigh systems are networked together and I have the ability to see, monitor, and control either system remotely. This is very important to our overall operation since I don't have to be there in person." Overall, Neibauer has been very impressed with the Ozone-On-Demand' approach, stating "Both systems have worked flawlessly to date with no system downtime."